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DEPARTMENT OF **EARTH AND ENVIRONMENTAL SCIENCES**
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Cloud radiative impact assessment over Greenland by active satellite remote sensing

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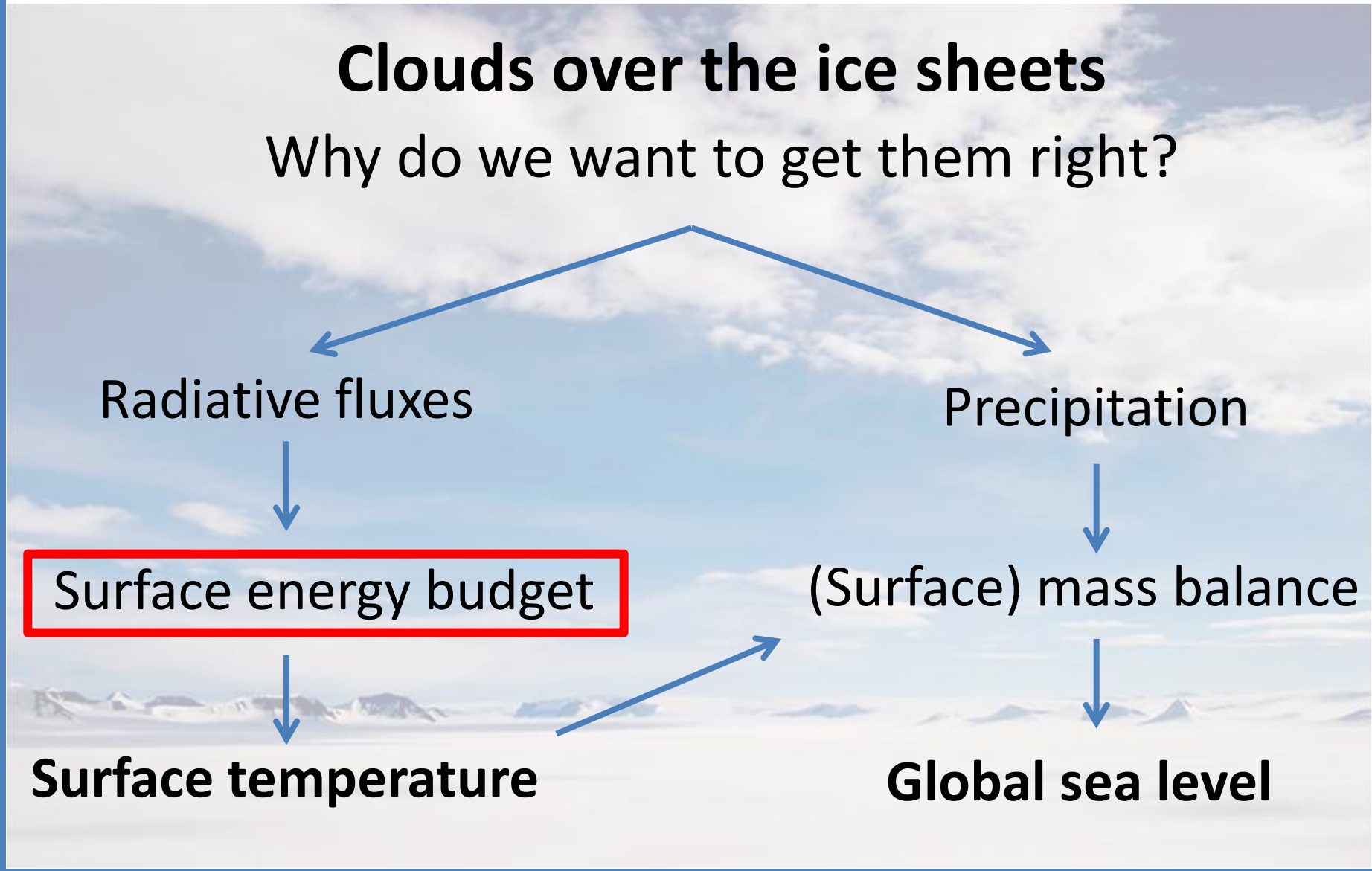
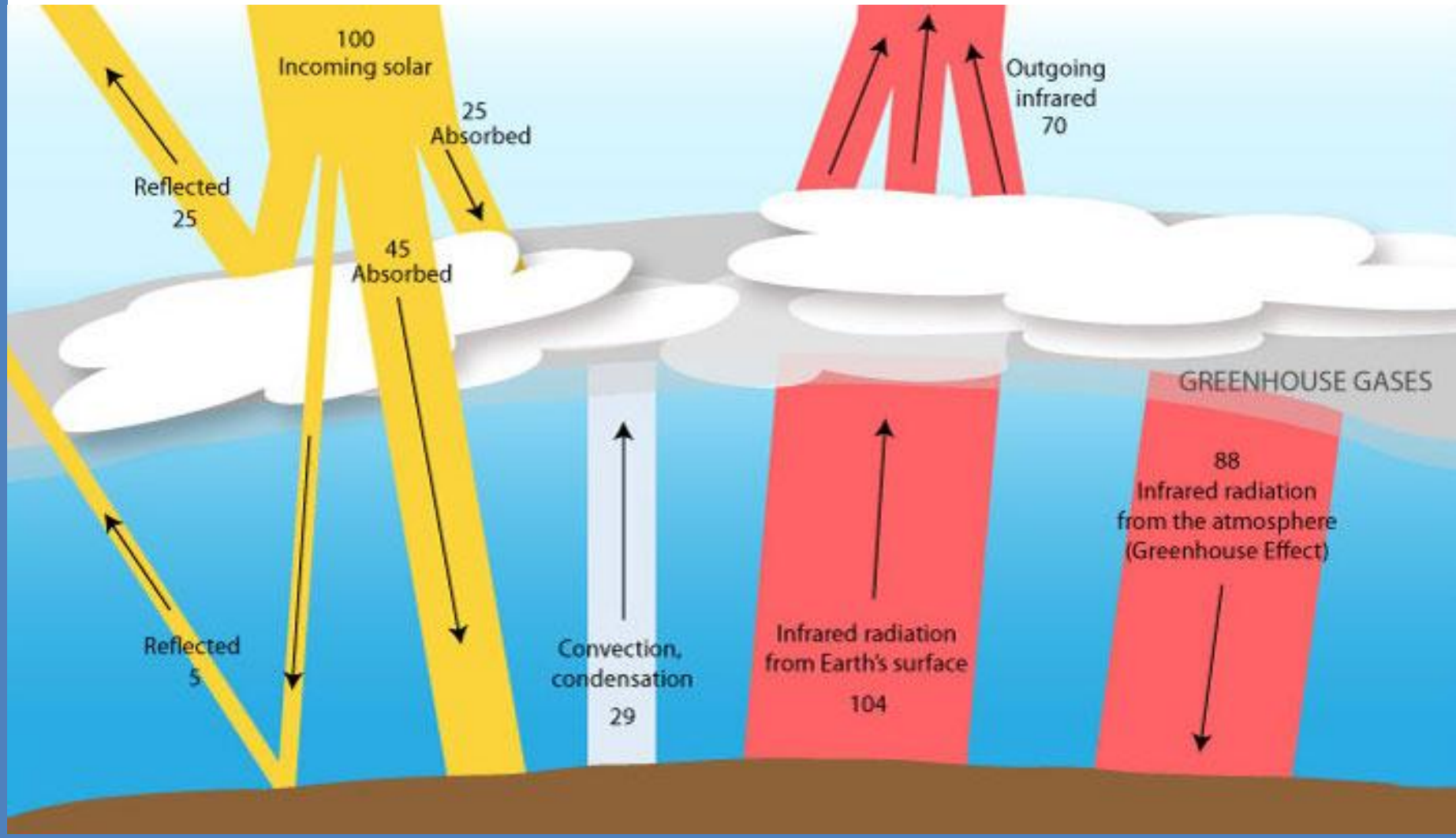
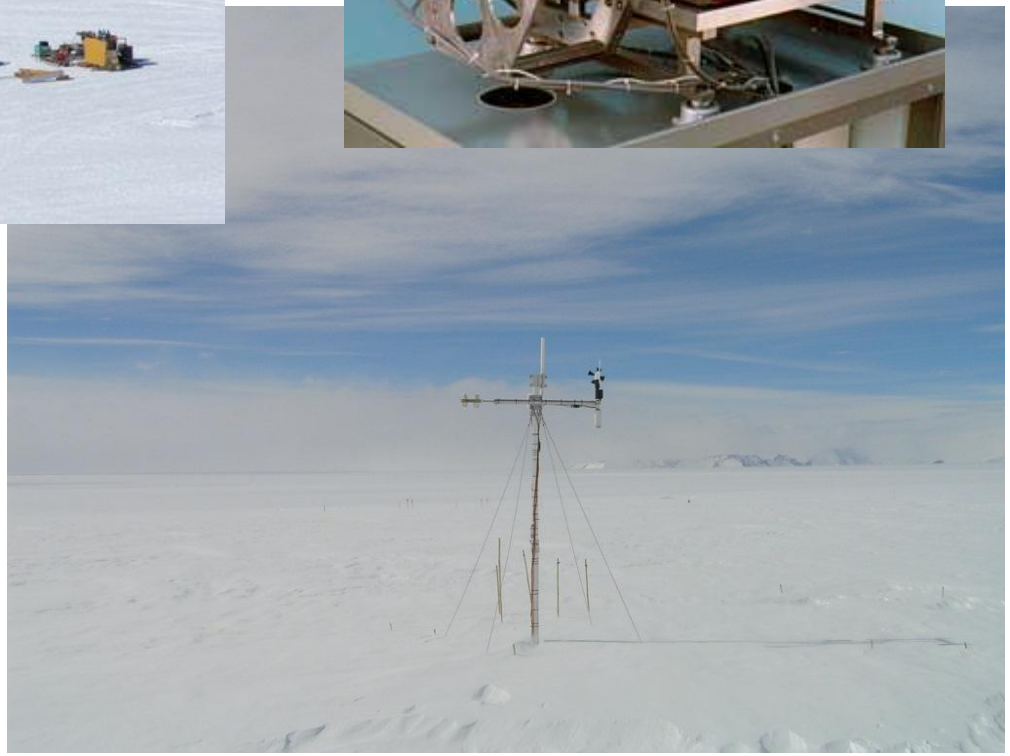
Introduction



Clouds affecting the energy budget



How do we ‘measure’ their effect?



From the ground

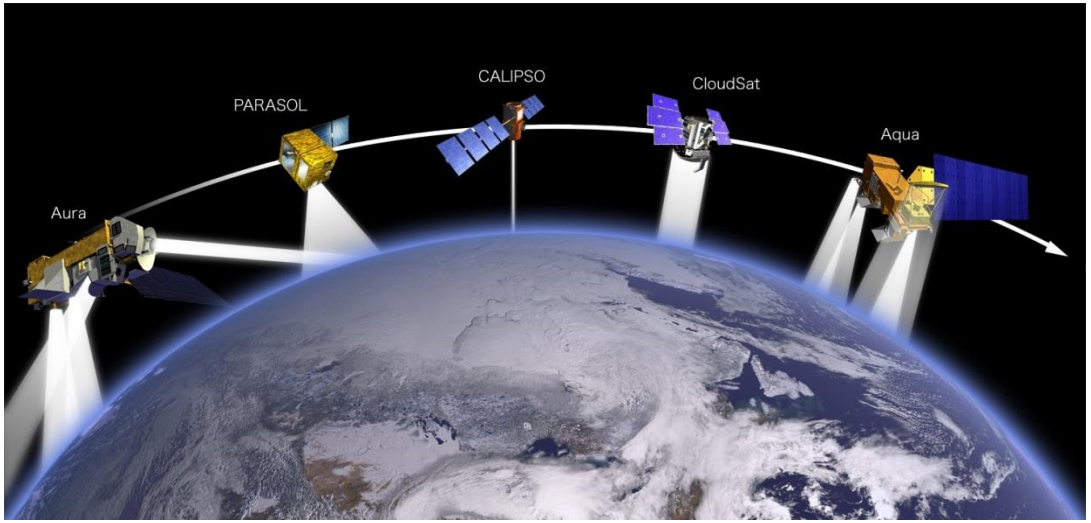
From space!

Since a few years, we have satellites designed to observe clouds!

Can they fill the observational 'gap' over the ice sheets?

- coverage
- temporal resolution

There are limitations!



Cloud observations by satellites

CloudSat and CALIPSO satellites

- Launched in 2006
- In close proximity
- Combination of active radar and lidar
- Designed to study clouds on a global scale

Data and methodology

1. AWS and PAERI ground-based data

2. CloudSat and CALIPSO satellite data

3. Satellite data → radiative fluxes

   The 2B-FLXHR-LIDAR algorithm

1. AWS and PAERI ground-based data

AWS stations:

→ SW/LW flux measurements

PAERI instrument:

→ infrared spectral radiance

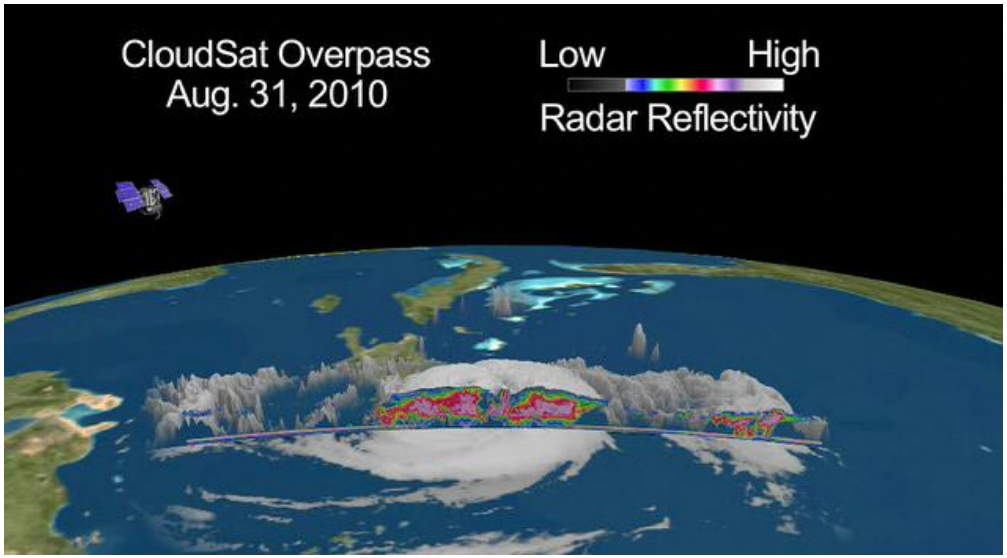
→ recalculated to LW flux measurements

PAERI

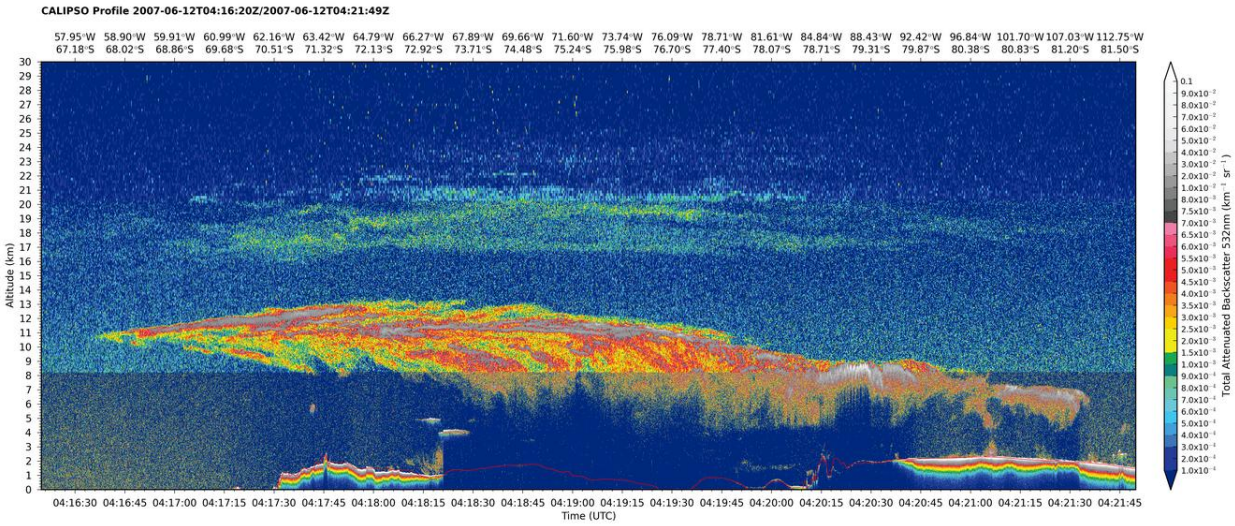

AWS

2. CloudSat and CALIPSO satellite data

CloudSat radar Reflectivity profiles



CALIPSO lidar attenuated backscatter profiles



3. Satellite data → radiative fluxes

Raw data are processed to different products:

1B-CPR	2B-CLDCLASS	2B-CLDCLASS-LIDAR	2B-CWC-RO	2B-CWC-RVOD	2B-FLXHR
2B-FLXHR-LIDAR	2B-GEOPROF	2B-GEOPROF-LIDAR	2B-TAU	2C-ICE	2C-PRECIP-COLUMN
2C-RAIN-PROFILE	2C-SNOW-PROFILE	2D-CLOUDSAT-TRMM	ECMWF-AUX	MODIS-AUX	

2B-FLXHR-LIDAR = Level 2B Fluxes and Heating Rates

Algorithm that uses
- Coupled **CloudSat/CALIPSO/MODIS/ECMWF data**

To calculate
- **Radiative fluxes** and heating rates at 126 vertical levels

3. Satellite data → radiative fluxes

For every vertical profile

Look for clouds detected by CloudSat/CALIPSO

Determine LWC/IWC

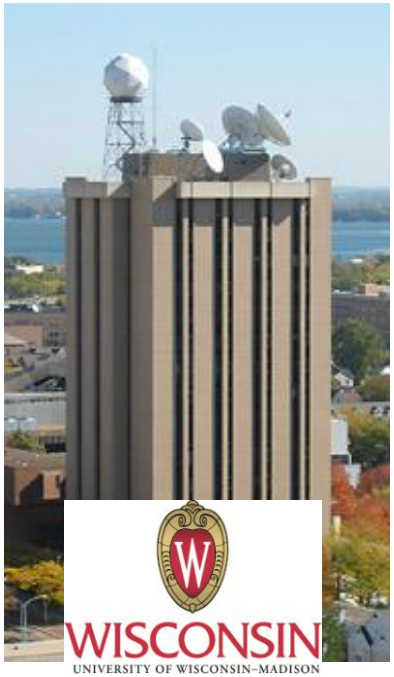
Run a two-stream RTM

Retrieve radiative fluxes

3. Satellite data → radiative fluxes

Include cloud **phase** information from **2B-CLDCLASS-LIDAR** product

1B-CPR	2B-CLDCLASS	2B-CLDCLASS-LIDAR	2B-CWC-RO	2B-CWC-RVOD	2B-FLXHR
2B-FLXHR-LIDAR	2B-GEOPROF	2B-GEOPROF-LIDAR	2B-TAU	2C-ICE	2C-PRECIP-COLUMN
2C-RAIN-PROFILE	2C-SNOW-PROFILE	2D-CLOUDSAT-TRMM	ECMWF-AUX	MODIS-AUX	

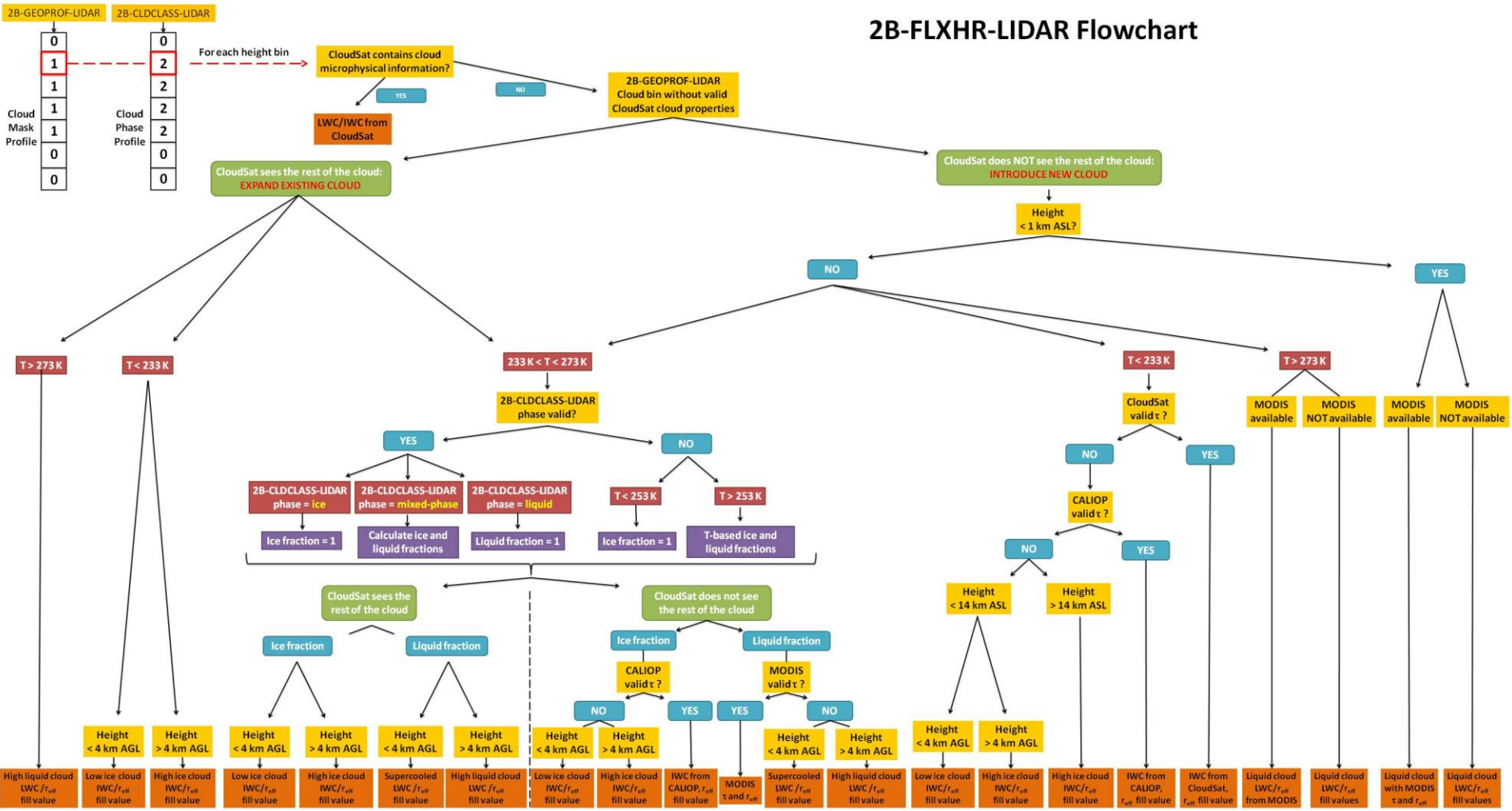


Cloud phase information:

all ice – all liquid – mixed-phase

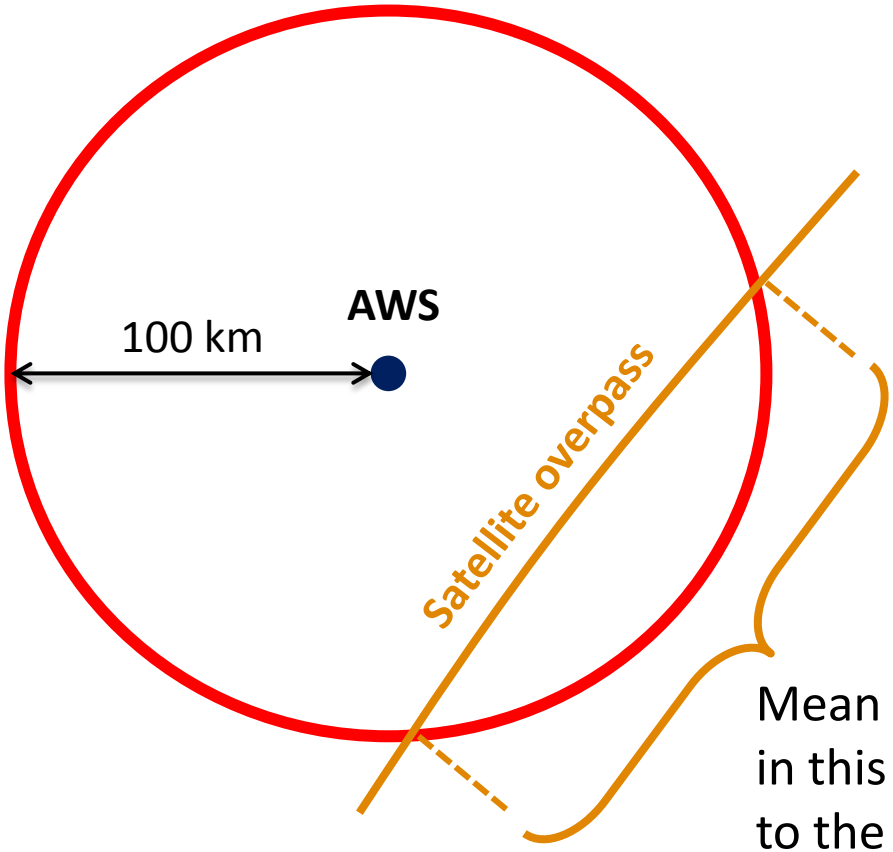
In collaboration with
The Atmospheric Radiation and Climate Research Group,
University of Wisconsin - Madison

3. Satellite data → radiative fluxes

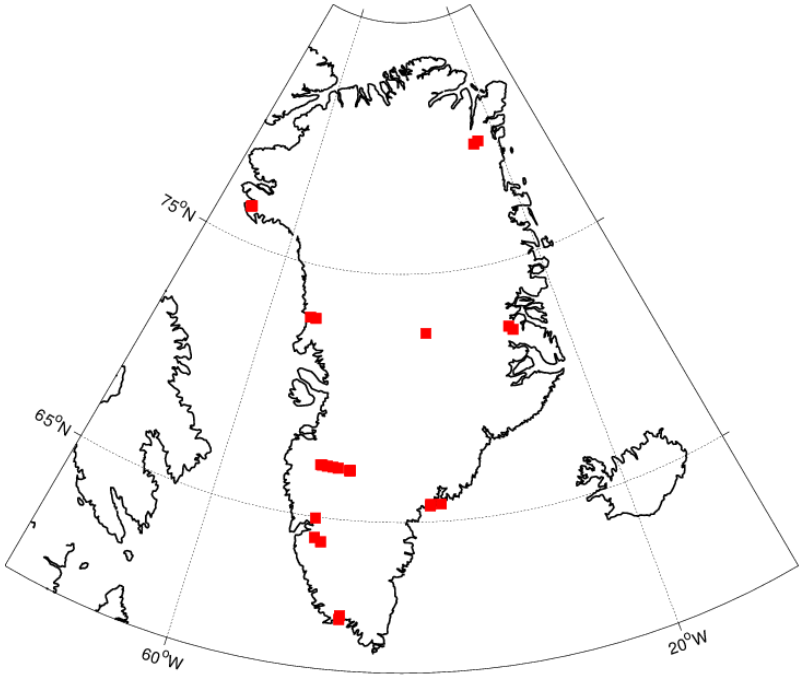


Dataset evaluation

For every available station,
For every overpass

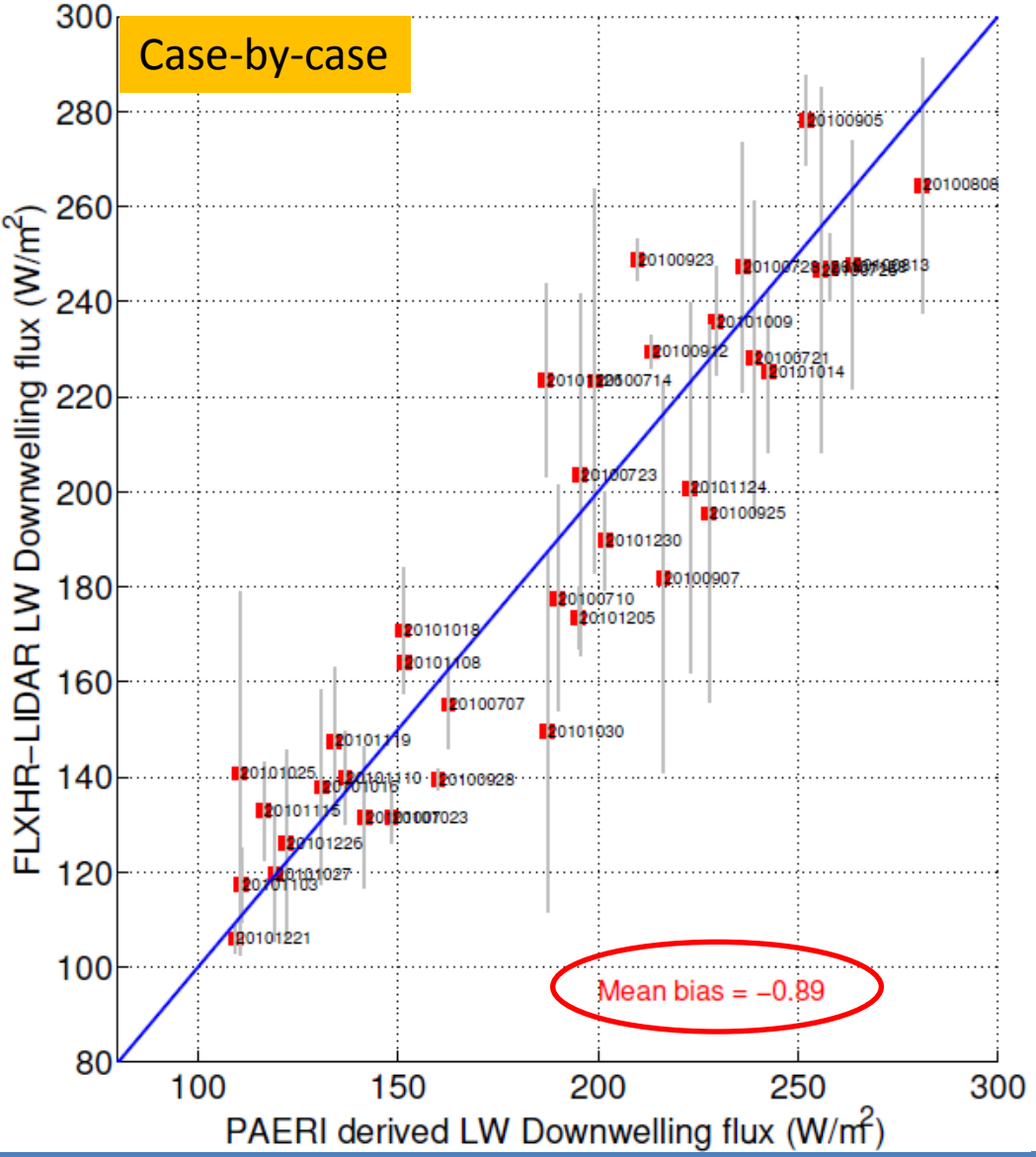


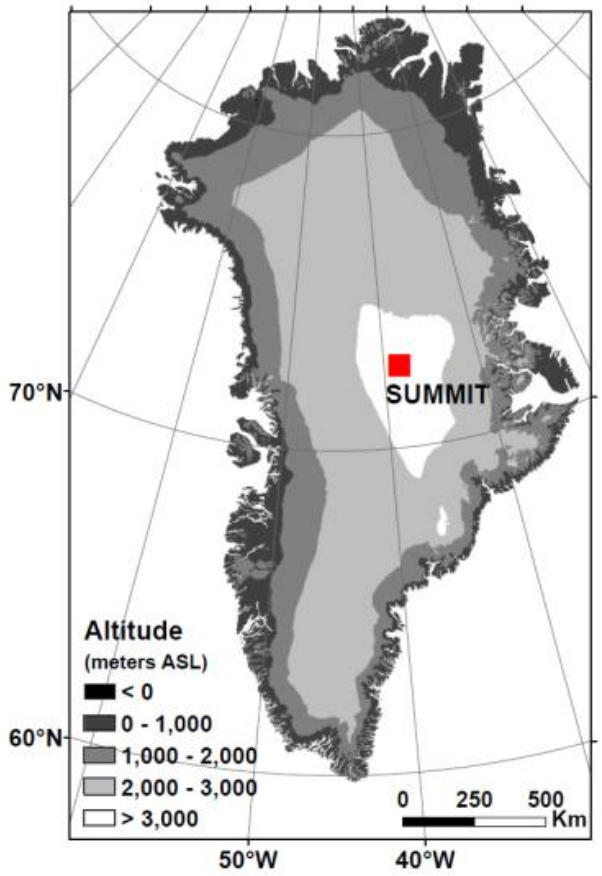
IMAU and GC-Net stations



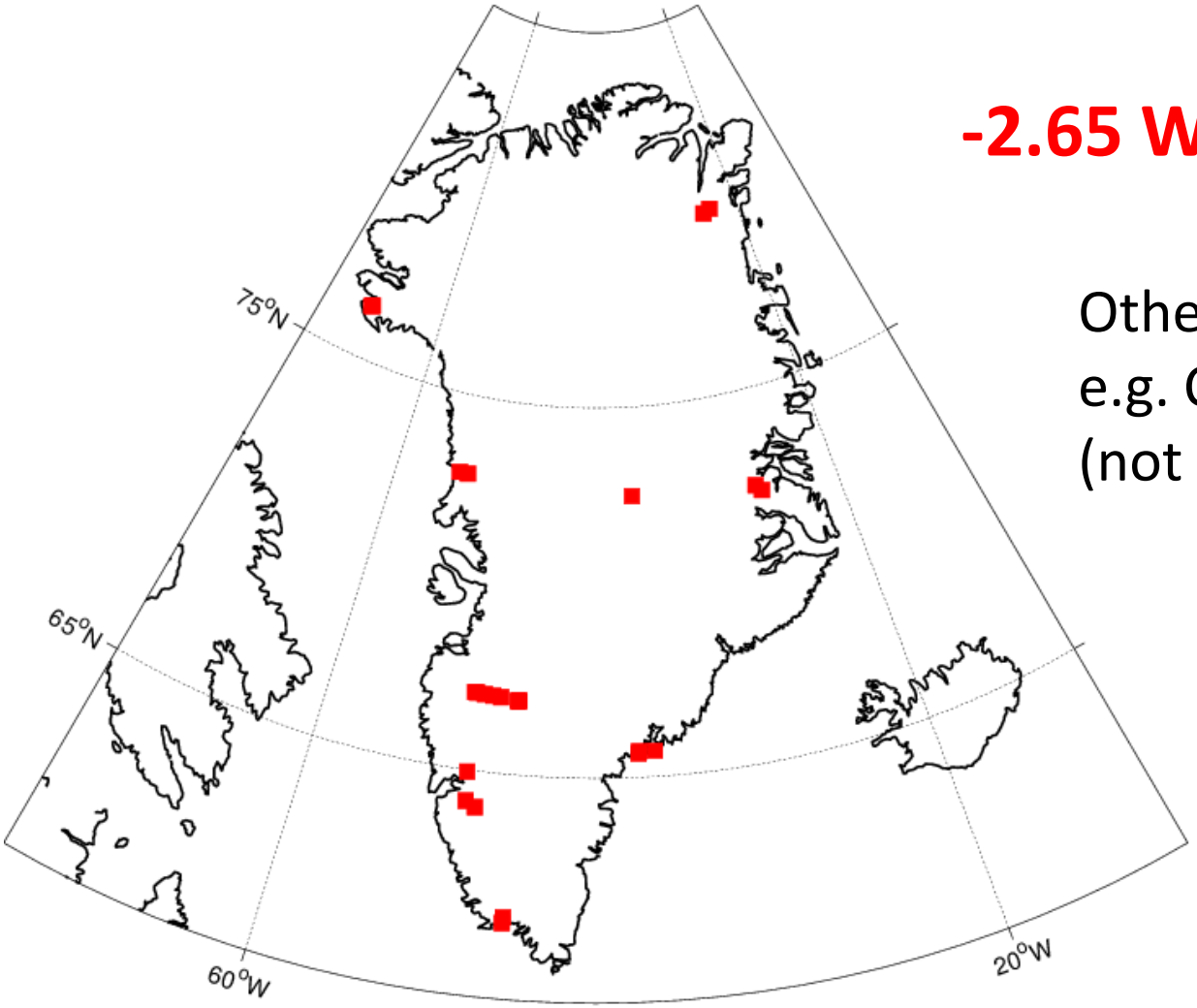
Mean and standard deviation of flux retrievals in this part of the satellite track are compared to the ground station

Evaluation of the radiative fluxes





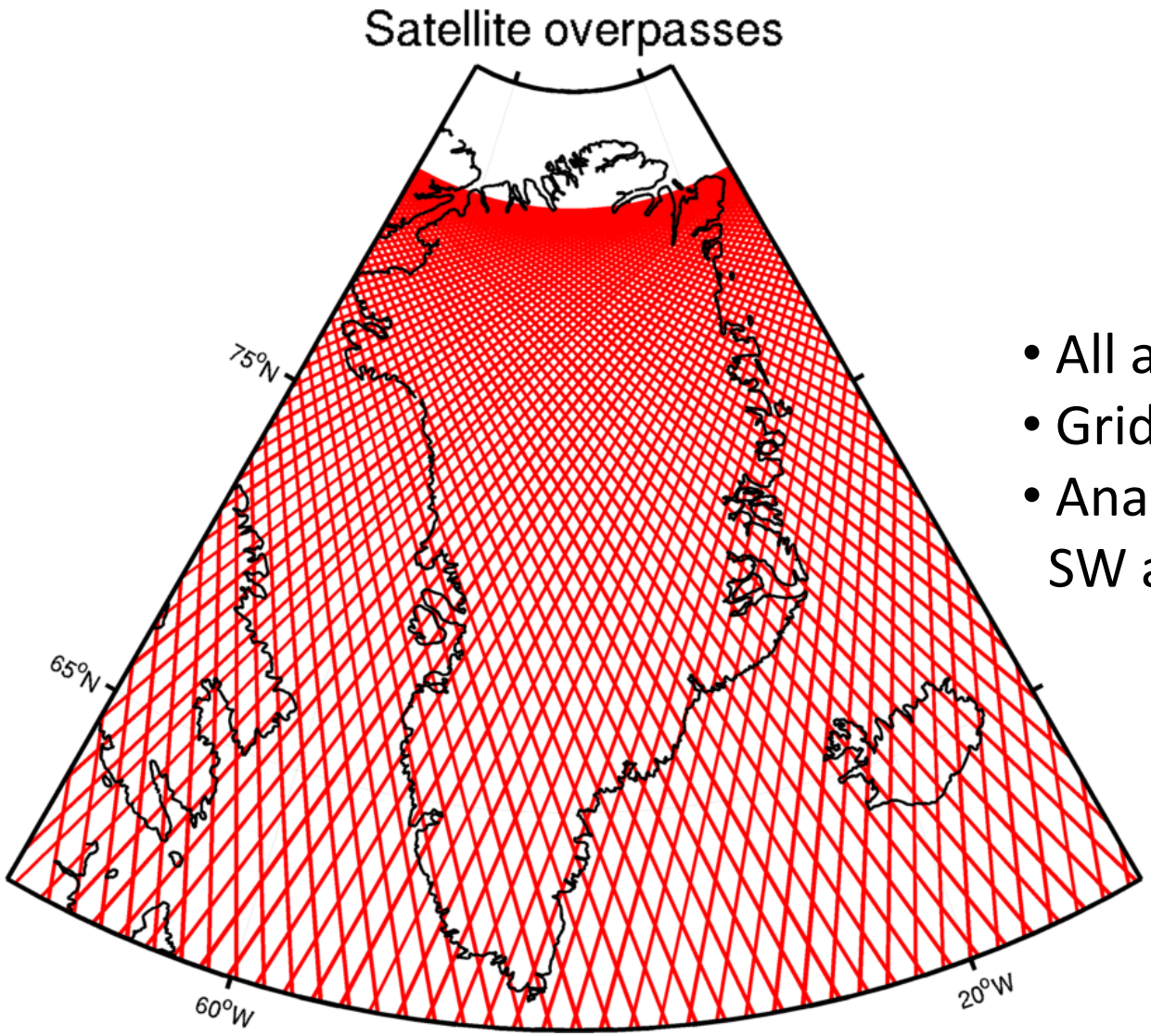
Evaluation of the radiative fluxes



-2.65 W/m² mean bias

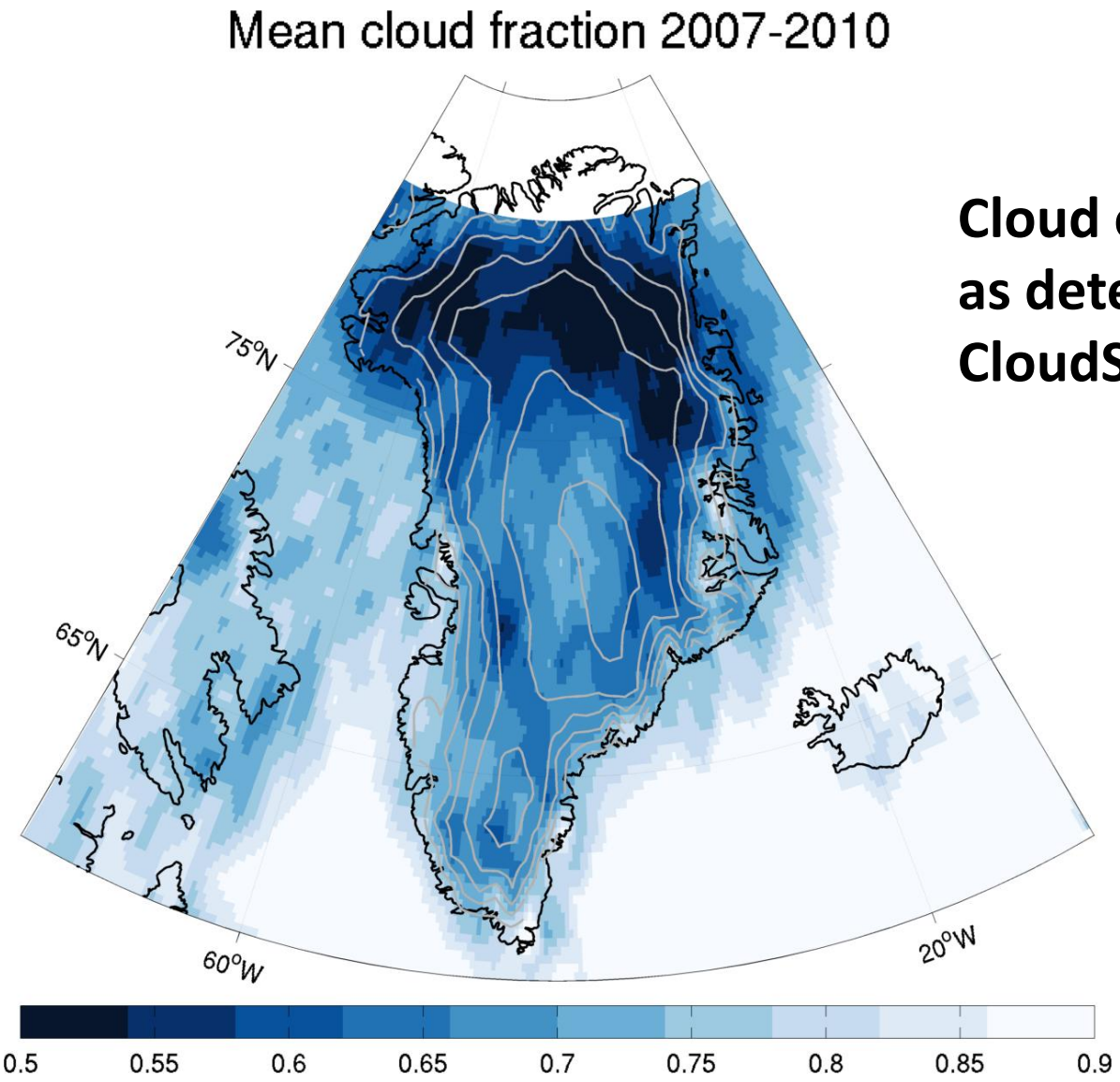
Other validations as well, e.g. CERES observations (not shown)

Applications over Greenland



- All available overpasses
- Gridded into 2° X 2° grid
- Analyses for clouds, SW and LW

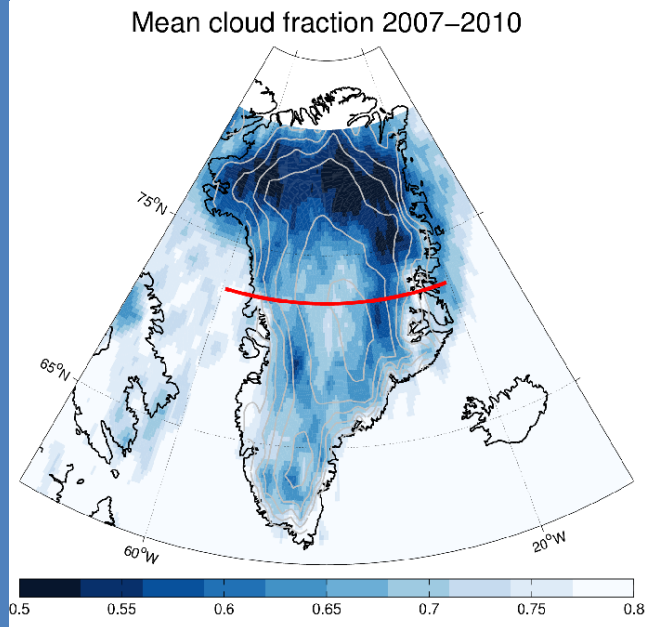
Applications over Greenland: clouds

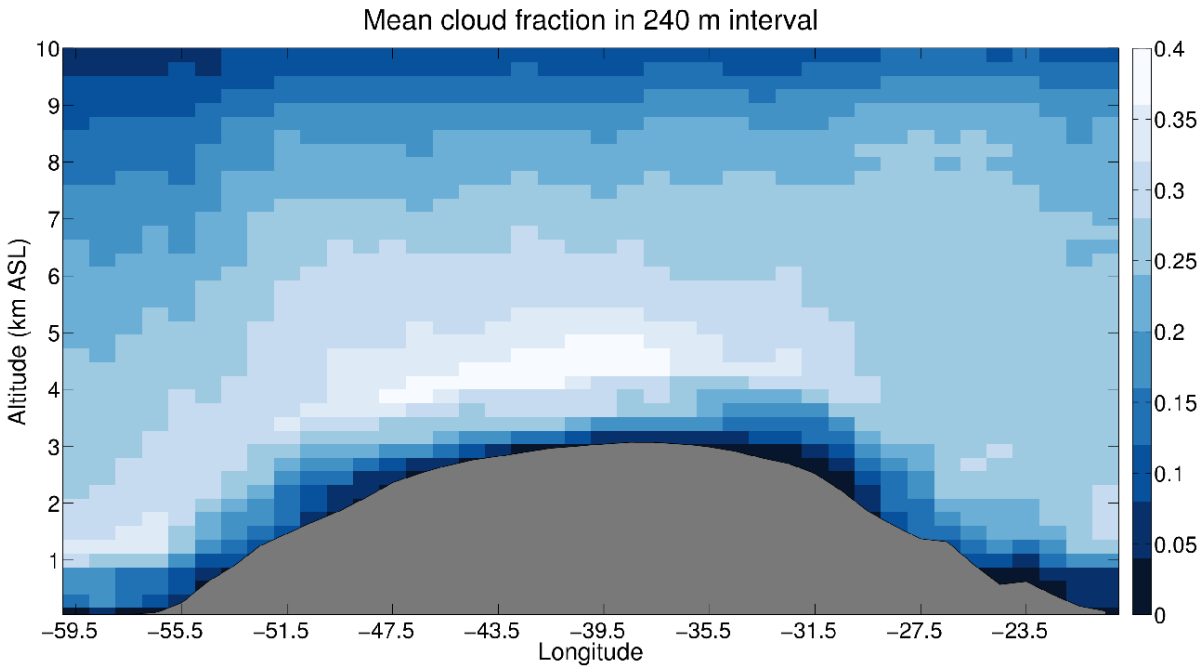


Cloud occurrence fraction as detected by CloudSat/CALIPSO

Application over Greenland: clouds

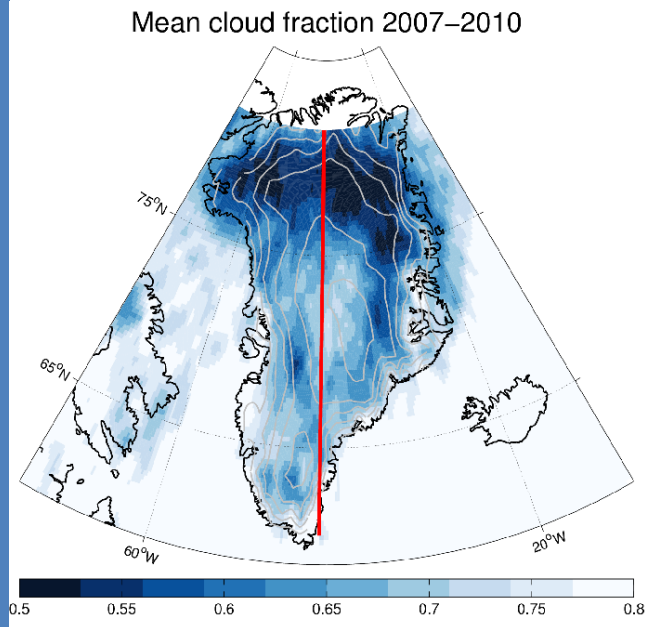
Detected cloud boundaries by CloudSat/CALIPSO

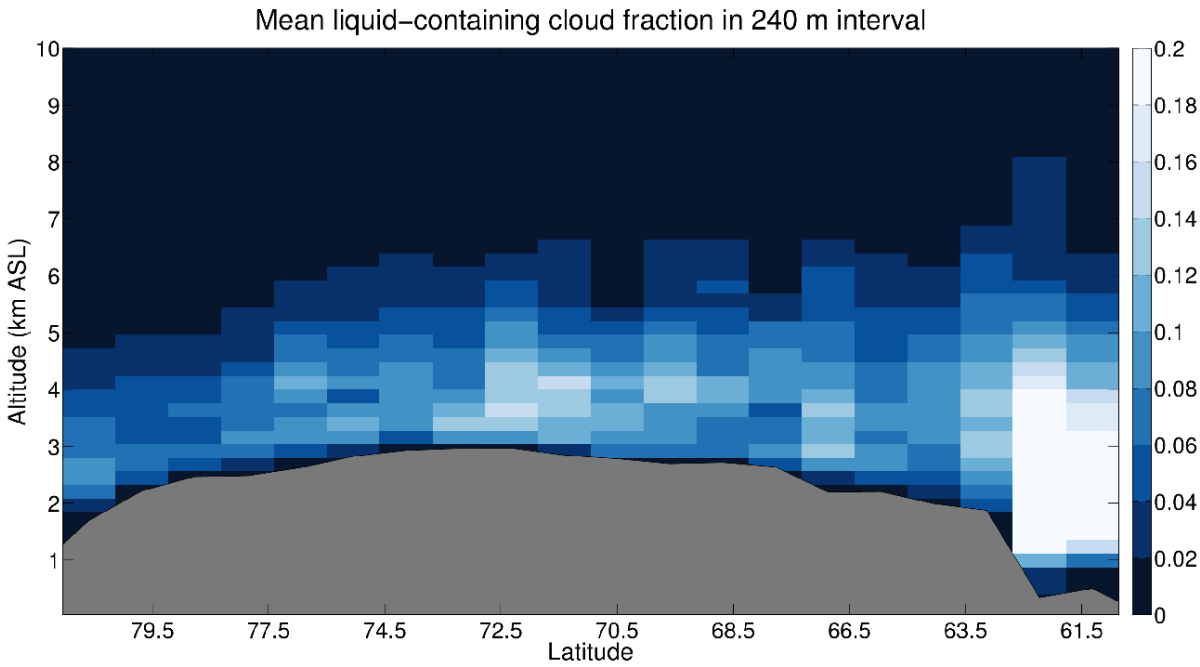




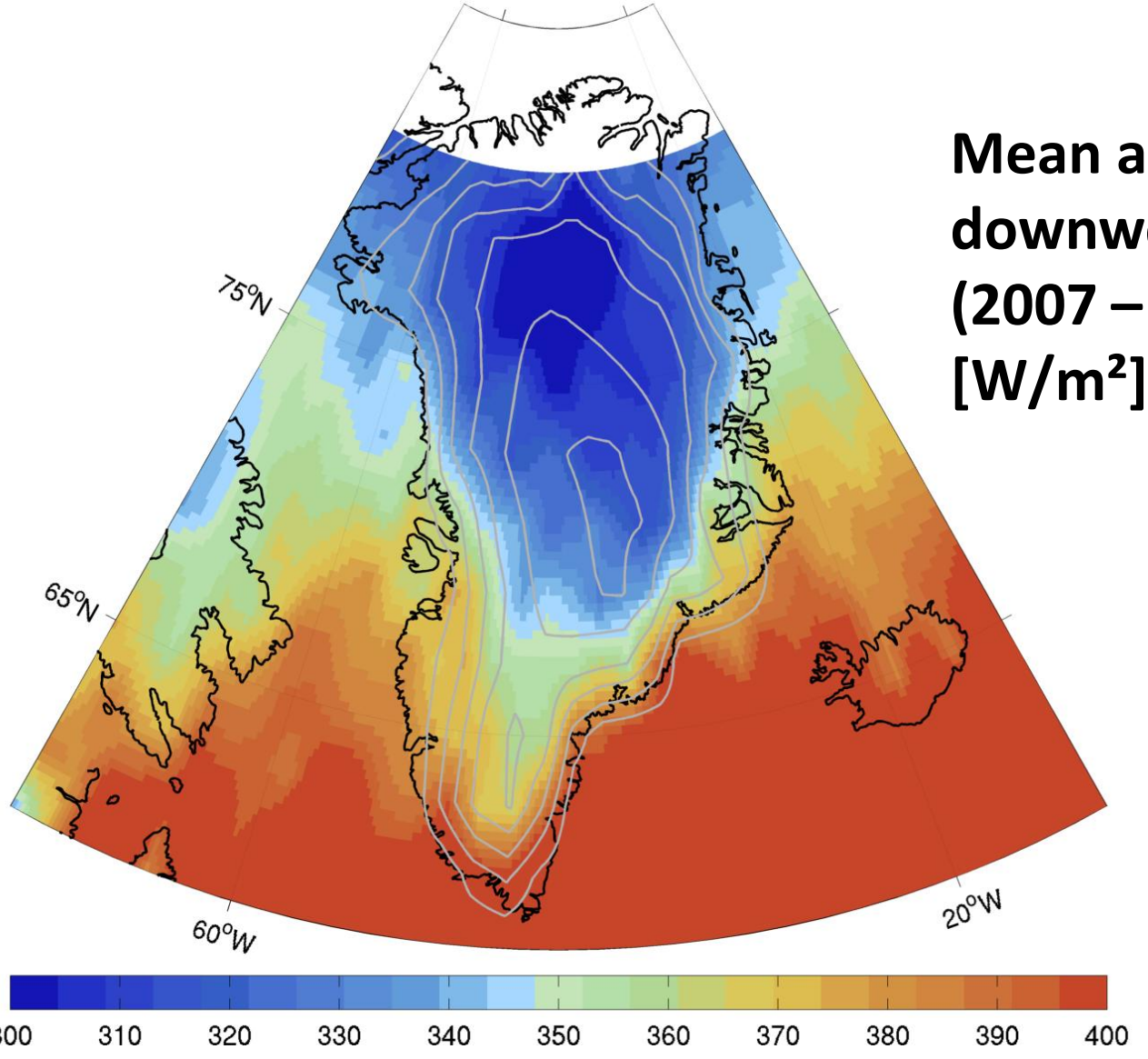
Applications over Greenland: clouds

Detected cloud phase by CloudSat/CALIPSO





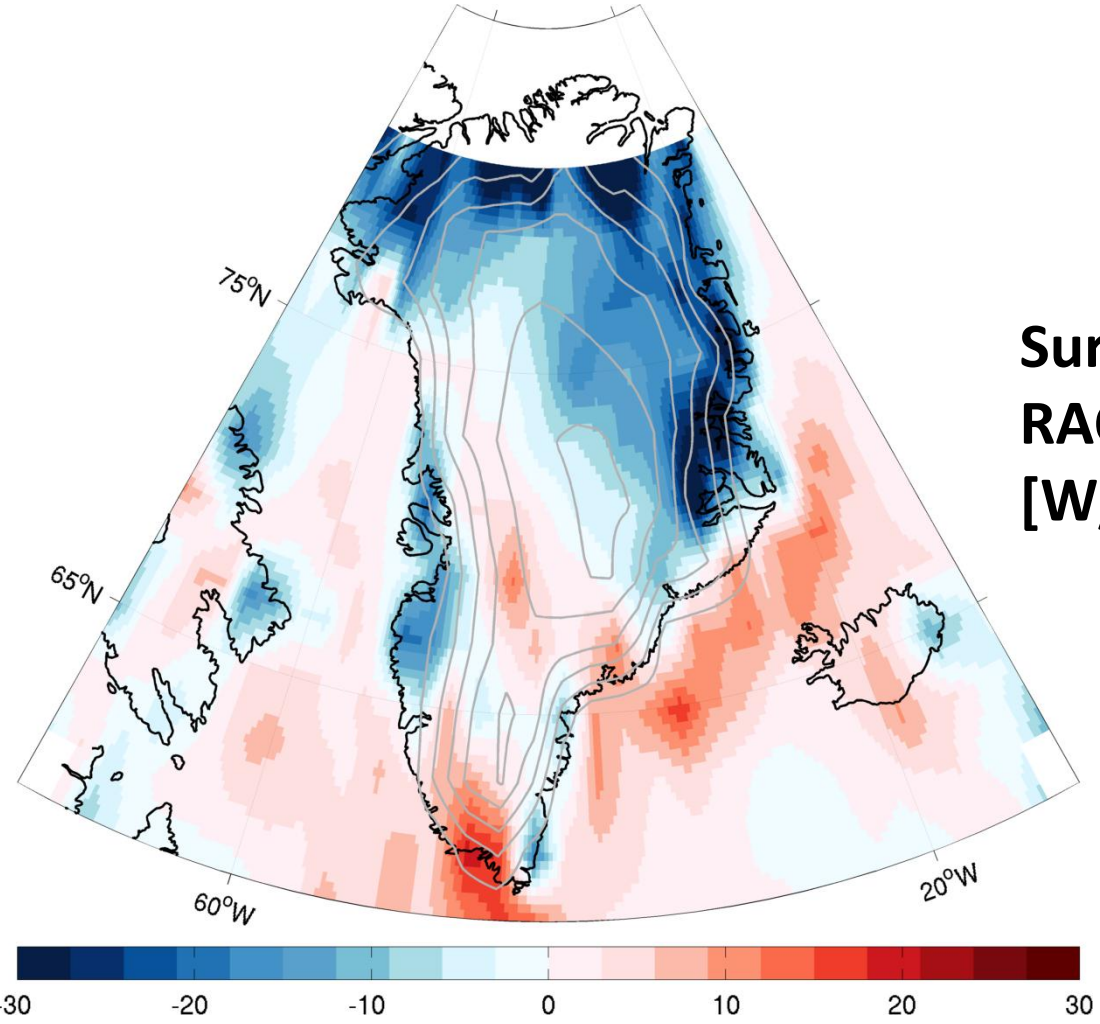
Applications over Greenland: radiative flux



Mean annual LW + SW downwelling surface flux (2007 – 2010) [W/m²]

Outlook

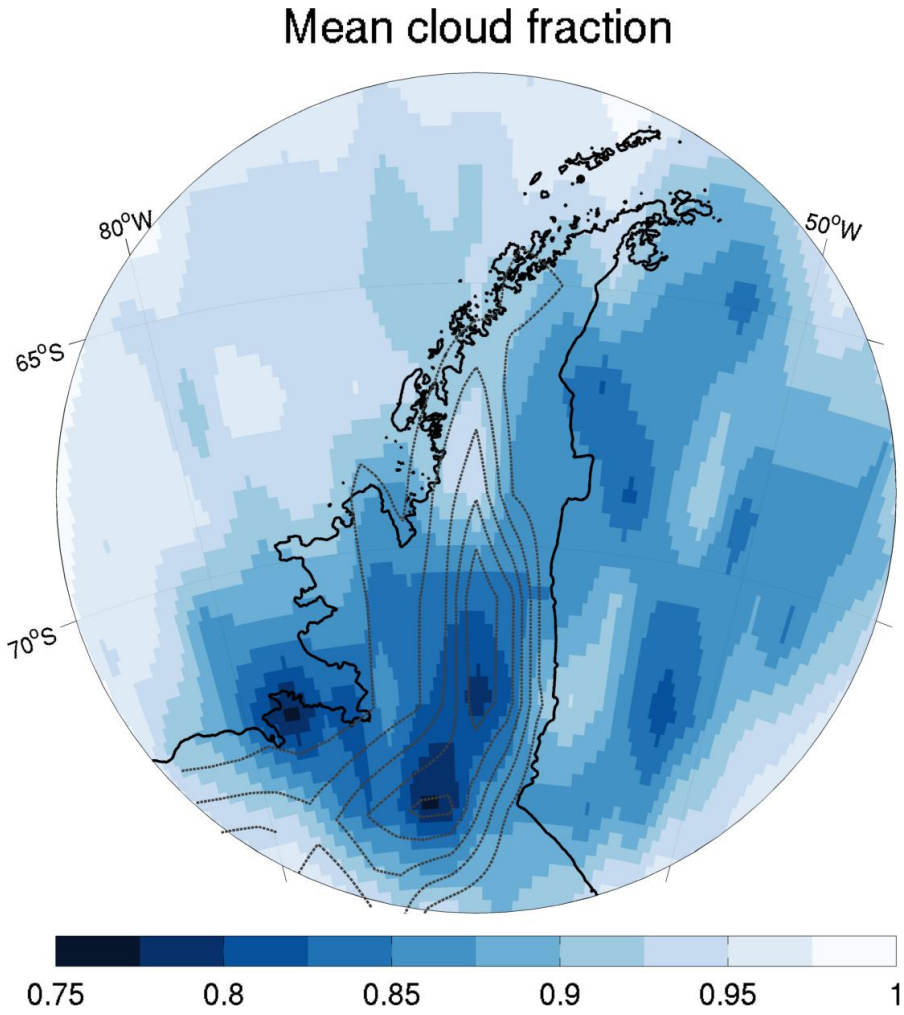
1. Evaluation of clouds in climate models



Surface downwelling LW flux
RACMO – FLXHR-LIDAR
[W/m²]

Outlook

2. Similar analyses for Antarctica



Mean 2010 cloud fraction as detected by CloudSat/CALIPSO

Conclusion

- Combined CloudSat/CALIPSO cloud observations can be used for accurate radiative flux retrievals
- This new dataset greatly enlarges the amount of observational data over the ice sheets
- These data can be used to evaluate climate models
- This in turn can help improving future climate projections over the ice sheets

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Thank you!

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